

Environmental Impact Assessment of a Coal-fired Power Plant at the Ulchin Site

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1. Introduction

The objective of the study is to assess the environmental impacts from a coal-fired power plant by using AirPacts. The AirPacts calculates the local damage costs for a radius of 60 km and regional damages up to a radius of 1000, as specified by the software. In this study, however, we have adjusted the regional damages to reflect a radius of 300 km, which covers approximately the boundaries of Korea

2. Methodology

The AirPacts model was developed by the IAEA as a simplified means of providing reasonable estimates of the environmental and health impacts of different fossil power plants, and to value the damages in monetary terms. The AirPacts program calculates the physical impacts and the associated damage costs for the following type of pollutants: particulate matter (PM), sulfur dioxide (SO₂), nitrogen oxides (NO_x), carbon monoxide (CO), and secondary species such as nitrate and sulfate aerosols. The primary or precursor pollutants (PM, SO₂, NO_x and CO) are emitted directly into the air at the source location. The damages are very sensitive to local conditions, particularly meteorological data (wind speed and wind direction) and receptor distribution (population, crop or material density). Secondary pollutants, those species formed in the atmosphere because of chemical transformations of primary pollutants, are rather insensitive to local characteristics because they typically form in the air tens of km downstream of the source. SO₂ is the precursor pollutant for sulfates and NO_x for nitrates.

3. Environmental Externalities of a Coal-Fired Power Plant

The Taehahn (500MWe) coal-fired power plant is used as the reference plant for calculating the external damages arising from the release of pollutants from coal-fired power plants. This plant has been hypothetically relocated to the Ulchin site. The plant is equipped with state-of-the-art precipitator and flue gas desulfurisation (FGD) facilities as well as low-NO_x fuel.

Airpacts calculates the damage costs for this plant for the following pollutants: particulate matter (PM₁₀), nitrate, and sulfate

AirPacts uses four categories for the input data: (1) emissions data(Table-1) (2) dispersion data(Table-2) (3)

receptor data(Table-3), and (4) health effects and unit damage costs data(Table-4).

Table-1 Emissions data

	Emission rates (tons/yr)	Depletion velocity (cm/sec)
PM ₁₀	174	0.67
SO ₂	1935	0.73
NO _x	4480	1.47
Sulfates	-	0.71
Nitrates	-	1.73

Table-2 Dispersion data

Source coordinates (Longitude/Latitude)	230.8/37.1
Source location	Rural
Stack height(m)	150
Stack diameter(m)	7.0
Flue gas velocity(m/s)	13.0
Flue gas temperature(K)	363
Anemometer height(m)	25
Air temperature(K)	286.4
Wind speed(m/s)	1.6

Table-3 Receptor data

Regional population(persons/km ²)	167
Local population(persons/km ²)	25
Radius of local domain(km)	60

Table-4 Health effects and unit damage cost data

	ERF	Unit cost (dollar per impact)
PM ₁₀ - Chronic Mortality	0.0004	39153
PM ₁₀ - Infant Mortality	1.80E-07	783046
PM ₁₀ - Chronic Bronchitis, cases	1.81E-05	156609
PM ₁₀ - Restricted Activity Days, (working adults, 15-64)	2.32E-02	102
PM ₁₀ - Restricted Activity Days, (non-working adults, 15-64)	2.63E-03	36
Nitrates - Chronic Mortality	2.00E-04	39153
Nitrates - Infant Mortality	9E-08	783046
Nitrates - Chronic Bronchitis	9.05E-06	156609
Nitrates - Restricted Activity Days, (working adults, 15-64)	1.16E-02	102
Nitrates - Restricted Activity Days, (non-working adults, 15-64)	1.32E-03	36
Sulfates - Chronic Mortality	4.00E-04	39153
Sulfates - Infant Mortality	1.8E-07	783046
Sulfates - Chronic Bronchitis	1.81E-05	156609
Sulfates - Restricted Activity Days (working adults, 15-64)	2.32E-02	102
Sulfates - Restricted Activity Days, (non-working adults, 15-64)	2.63E-03	36

4. Result & Discussion

AirPacts was designed to calculate the external costs from a plant irrespective of the national borders. This covers a region far beyond the borders of Korea, whereas Korea is the limit of our interest here. We have therefore calculated the total impact first and then scaled it down to a 300 km regional domain which covers only Korea. Since the traveling distances for different pollutants are different, the scale-down coefficients are also different. Scale down coefficients, i.e., the ratio of a impact within a 300 km domain to a total impact, are calculated as 0.44 for PM10, and 0.09 for the sulfates and nitrates.

The results shown below are adjusted for the 300 km radius, by applying the applicable scale-down coefficients to the regional impacts calculated for each pollutant.

Table-5 shows the annual health effects from a year's operation of the Taeahn coal-fired power plant (500MWe) at the Ulchin site. Restricted activities days caused by nitrates comprise the greatest impact in terms of the number of cases (180,000), followed by the sulfates. However, in terms of the monetary damage costs (Figure-1), it is chronic mortality caused by the nitrates that ranks highest, amounting to about \$2.3 million US/ year.

Table-5 Annual health effects

Pollutants	Health impacts	Units	Local	Regional
PM10	Chronic Mortality	years of life lost	0.42	21.12
PM10	Infant Mortality	Cases	0.00	0.01
PM10	Restricted Activity Days	Days	27.24	1 366
PM10	Chronic Bronchitis	Cases	0.02	0.96
Nitrates	Chronic Mortality	years of life lost	n/a	60.15
Nitrates	Infant Mortality	Cases	n/a	0.03
Nitrates	Restricted Activity Days	Days		3 889
Nitrates	Chronic Bronchitis	Cases	n/a	2.72
Sulfates	Chronic Mortality	years of life lost	n/a	21.32
Sulfates	Infant Mortality	Cases	n/a	0.01
Sulfates	Restricted Activity Days	Days		1 379
Sulfates	Chronic Bronchitis	Cases	n/a	0.96

The total damage costs from the Taeahn plant amount to some \$5.2 million US per year (Figure-1). Local damages from NO_x and SO₂ are negligible as these pollutants are chemically transformed into nitrates and sulfates and their damage potential to human health increases as they travel from a source, 60 km being about the accepted range for this process to start. Virtually all the damages from this plant occur at the regional level from secondary pollutants, mainly (\$3 million) from nitrates.

The total damage costs in 2004 for the Taeahn plant translated into 0.15 cents/kWh. This figure is some

3.7% of the actual 2004 generation cost (4.0 cents/kWh) for this plant.

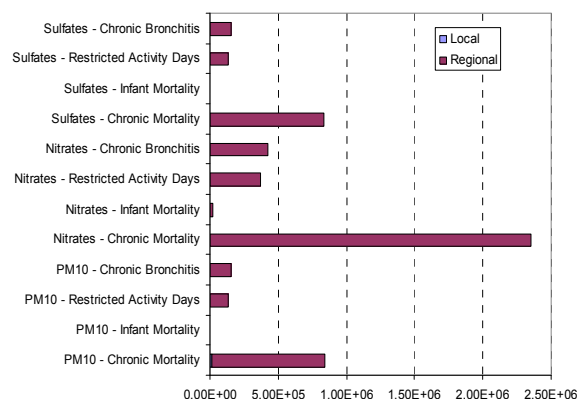


Figure-1 Health effects of a coal-fired power plant (\$ per year)

6. Conclusion

The external damage cost per unit of energy generated by a coal-fired power plant is estimated. The greatest damage from the plant is at the regional level, from nitrates. Although this analysis is not complete, it does provide insights into the environmental effects caused by a normal operation of a power plant. The external cost can be used as an important factor for the investment decisions, technology assessments, and cost-benefit analyses for policies and measures that reduce environmental and health impacts.

REFERENCES

- [1] ExternE Externalities of Energy(Methodology 2005 Update), EUR 21951, 2005
- [2] AirPacts Manual, IAEA, 2005
- [3] KOSIS data, Korea National Statistical Office, 2005